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Cadmium, A Health Hazard Surface Treatment

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1 Introduction

The use of materials involving health risks represents a health risk in general and an environmental risk.

In some instances restrictions have been imposed on the marketing of materials that are injurious to health and on the use of specific hazardous materials and their processing. This is the case with asbestos, PCB/PCT, cadmium and cadmium alloys etc. These restrictions are published within the European Union in what are known as EEC Directives (EEC 76/769). If individual countries within the European Union wish to adopt these restrictions, these restrictions have to be implemented by passing legislation at a national level.

Implementation of this EEC Directive under German law resulted in the Chemicals Prohibitory Regulation (Chemikalien-Verbotsverordnung).

Thus, for example, cadmium and its alloys must not be marketed pursuant to this EEC Directive and the Chemicals Prohibitory Regulation. However, the present legal situation does allow a few exceptions.

One exception, for example, is aerospace, where cadmium may still be brought into circulation and used.

This affects the military sector to an equal extent. Cadmium is still used today for surface treatment (corrosion protection) in a large number of weapon systems.

Hazards to humans and the environment arise from cadmium in the following specific processes:

- manufacturing (electroplating processes)
- maintenance and repair jobs and
- disposal, of course.

2 Cadmium-Related Health Risks

What then are the actual risks caused by cadmium?

I would like to deal briefly with this question and then explain those characteristics of cadmium which are injurious to health in greater detail:

Cadmium is a chemical element and is a silvery white, shiny, soft and ductile metal.

In view of its good characteristics for corrosion protection, cadmium is frequently used as a treatment for metal surfaces.

An object containing cadmium is not especially injurious to health on its own. No risk is involved simply by touching it.

A potential hazard occurs, however, when such objects are processed and high temperatures are generated.

The reacting capacity of cadmium with oxygen at high temperatures results in cadmium oxide.

Cadmium oxide is formed during grinding, filing and welding operations, for example.

The fumes of cadmium oxide get into the human organism upon inhaling.

One aspect which should not be ignored is the cadmium-plating process and also the waste disposal of items containing cadmium. This is the way into the environment.

Our health may be influenced by an accumulation of cadmium and cadmium alloys in our body.

Thus cadmium poisoning results in:

- impairment of liver and kidneys (in view of accumulations)
- impairment of the gastrointestinal tract
- impairment of the respiratory tract (pulmonary oedema) upon inhaling cadmium-oxide fumes.

In addition, there is a risk of chronic poisoning such as:

- inflammation of the mucosa (known as the "cadmium cold")
- destruction of the olfactory epithelia
- bone defects

And, what is more, there is the suspected risk of a carcinogenic effect. This has been:

- clearly proved in experiments on animals, and therefore
- a carcinogenic risk cannot be ruled out for humans.

In view of these facts, cadmium *clearly* represents a health hazard to humans which must not be underestimated.

In future, therefore, parts containing cadmium are required to be replaced by parts which are free from it.

3 Alternatives to Cadmium

The non-use of cadmium raises technical and economic issues.

- Is there a comparable substitute?
- What is the price of such a substitute?

With regard to the first question:

Yes, there are comparable substitutes, such as zinc and zinc-nickel platings, or even alloyed special steels.

With regard to the second question:

Alternative products hardly differ in terms of prices.

There are therefore no significant reasons for continuing to use cadmium.

4 "Health Hazard Cadmium" Project

The health risk emanating from cadmium provided the impulse for the Health Hazard Cadmium project.

Its objectives were to identify all units of equipment fit containing cadmium in the Tornado aircraft and to work out a concept for substituting the units affected.

4.1 Procedure for Identifying Assemblies Containing Cadmium

4.1.1 Compilation of a comprehensive Tornado Database

The approach we adopted was as follows.

First, a comprehensive Tornado database was compiled for this purpose.

For the compilation of this database, all available data sources were analysed and the logistical information were compiled with a view to the assemblies and parts containing cadmium

4.1.1.1 Data Sources

The following digital data sources were selected and evaluated for compiling this full database.

- Integrated Logistics Information System: ILIMS (Logistics Office of the German armed forces)
- Codification Project Number Directory (Logistics Office of the German armed forces)
- Illustrated Parts List: IPL (Materiel Office of the German Air Force)
- Illustrated Parts Catalogue: IPC (Materiel Office of the German Air Force)
- NATO Codification Coordination Tornado Data (CoCo Tornado) (Logistics Office of the German armed forces)
- Machine Decoding System: MDV, Characteristics of an item (Logistics Office of the German armed forces)
- Federal Logistics Data: FedLog (General Information System)
- Item of Supply Information System: ISIS (Defence Codification Agency)

- NATO Master Cross Reference List (NMCRL) (General Information System)
- Life Extension Tornado: LExTOR (ESG internal)
- Material Information Service: MID (ESG internal)
- Material Management System: MABS (ESG internal)
- Tornado Technical Publication (ESG internal)

This comprehensive Tornado database holds about 11.5 million data records at present and requires approximately 18 GB of storage space.

4.1.2 Identifying the Assemblies and Assigning the Parts

Using specific data fields, all the **assemblies**, **not parts**, in the Tornado aircraft are identified from this database.

The corresponding **parts** were then assigned to the assemblies.

Assignment was performed using a special data field named **Project Number**.

4.2 Identifying Assemblies Containing Cadmium

We have now come to the crucial point - identification of the assemblies containing cadmium.

To be in a position to classify an assembly as containing cadmium, it is first necessary to assess the individual components for cadmium.

But how is it possible to tell whether a part contains cadmium or not? It is not just a question of telling from a data record in a database whether a part contains cadmium.

At this point I would like to draw attention to the fact that the entire Tornado aircraft is involved, with several million data records.

4.2.1 Assessing Parts

The purpose of our procedure was to provide information on which parts contained cadmium and which did not.

Several methods were used for identification purposes.

4.2.1.1 Industry Surveys

First of all there were surveys of industry of different kinds. Letters were sent to component manufacturers, equipment manufacturers and repair companies.

They were requested to provide information regarding cadmium in their components and assemblies.

The surveys showed that component manufacturers were very co-operative by providing information on their parts which contained cadmium and those that did not.

We had a few problems with equipment manufacturers and repair companies.

Either the questionnaires were not completed or horrendous sums were asked for answers.

Only a few were prepared to provide information at a realistic cost-performance ratio.

4.2.1.2 In-House Procedures at ESG

A further, and very successful, method was the in-house procedure at ESG of assessing parts for cadmium.

This method involved retrieving the requisite data by means of specific database queries.

Using widely-ranging query routines which clearly exclude cadmium and routines which clearly point out cadmium, two groups were formed:

- a group of parts **not** containing cadmium, and
- a group of parts containing cadmium

The volume of data that had to be assessed was thus successively reduced.

4.2.1.2.1 Query Criteria

For forming these two groups, an in-depth analysis was performed on the different data elements and the contents of the different data fields.

It became apparent that the following data elements and data fields are suitable for an assessment.

Names

The name of an item of supply, for example, provides information on the group to which the item has to be assigned.

Names such as "O-ring, Neoprene", "Insulating Piece" etc. indicate that the parts do not contain cadmium.

Other names like "Nut cadmium plated", "Washer cadmium" are clear.

Descriptive Information

The descriptive data are likewise very important.

Descriptive data characterise a part in greater detail in respect of its features and characteristics. Thus it is possible to find information on the dimensions, type of housing and, in some cases, the **surface treatment**. Cadmium and non-cadmium parts can now be acquired by these methods.

Standards

Analyses of standard parts – for example, PAN, DIN, LN, ISO, and VG - were also referred to for the purpose of assessing parts. The majority of standards contain a "Material Identifier"

which makes it possible to draw conclusions on the **material itself** or on its **surface treatment**. Sometimes a whole group of standards provides information on the material used.

Part Number

It is possible to determine, from the way in which some part numbers are written, whether they relate to cadmium or non-cadmium parts. **Words** such as nylon, PVC, insulating or cadmium-plated, and **material identifiers** and **abbreviations** such as GALZN, CRNI, B2A, B1B, GALCD, which are included in part numbers in many cases, are a guide to classification with regard to cadmium.

Group/Class

Further, certain groups and classes such as "All Rubber and Cushion Tyres", "Fibre Ropes, Cordage and Strings", "Packing and Sealing Material", "Non-Metallic Tubing and Branch Pieces", "Chemicals" etc. do **not contain cadmium parts** and thus come under the category of non-cadmium parts.

Code

Data fields with specific codes such as the **unit of issue code** can help identify **non-cadmium** parts. All parts whose code specified a **liquid** were placed in the non-cadmium category.

5 Results

What were the results of the identification:

The results of the identification were the Cadmium-Database.

This database contains the assemblies which contain cadmium including there parts containing cadmium.

It further became evident that the results of the in-house procedure at ESG were in very good agreement with the results of the industry surveys.

The distinct advantages of the in-house method at ESG are ascribable to the database procedure, which results in a cost-effective result.

A quantity assessment of the results shows, that 72 % (of 1736, 1249 contain cadmium) of the assemblies of the equipment fit contain parts containing cadmium.

28 % of the assemblies are cadmium free.

Further on an analyses of cadmium parts shows, that 10.542 parts contain cadmium.

If it is taken into account that the parts are used more than once, cadmium parts are to be found at approximately 1.2 Mill locations at the present time.

The components containing cadmium are predominantly attaching parts and common-fit items such as screws, nuts, washers and electrical connectors which, of course, are frequently used on an assembly.

The number of design parts is low. Furthermore, they normally occur only once on an assembly.

The identification phase has already been implemented and accepted.

The following section describes a concept that has already been discussed. Substitution has not been implemented so far and will take a while. The problem is the legal situation in the European Union, which is not yet as strict with regard to marketing and using cadmium as it is with asbestos and PCB/PCT etc.

6 Concept for Substitution

How does one proceed to come to terms with a relatively manageable number of parts with a high frequency of occurrence with regard to substitution?

An important criterion with regard to substitution is categorisation of the assemblies.

Two criteria could be taken for this categorisation:

- Assemblies with many cadmium parts,
- And assemblies which have a high number of contacts with cadmium in the course of maintenance work.

The maintenance work is an important criterion because during this work personnel come in contact with cadmium.

There is a permanent health risk if you work with parts containing cadmium !

The next step is designed to select pilot assemblies on the basis of these criteria.

The substitution should be realized together with the manufacturer of pilot assembly.

After the conversion the pilot assemblies should be subjected to functional testing.

The assemblies will be subjected to the different modification stages in the course of substitution. Requalification of an assembly will be initiated upon commencement of substitution by means of an EMAPF (Equipment Modification / Alteration Proposal Form) and will be completed upon successful conclusion of substitution.

Since the components containing cadmium are primarily common-fit parts (screws etc.), substitution can be performed at reasonable cost during repair activities.

After the pilot phase the substitution goes on with assemblies - first which have high priority than medium priority, than low priority.

Assemblies which include completely isolated parts containing cadmium and with which technical personnel do not come into contact have not been scheduled for substitution for cost reasons.

The experience which is made during the substitution phase should be used for the the other assemblies.

With this procedure the Tornado could be freed from cadmium step by step.

This method is suitable for identifying and substituting hazardous materials - in the civilian market as well as the military sector - at any time.



**Approaches to the implementation of environmental
pollution prevention technologies at military bases**

Cadmium, A Health Hazard Surface Treatment

May 05 - 07 1999
Budapest



Overview

- Introduction
- Cadmium-Related Health Risks
- Alternatives to Cadmium
- „Health Hazard Cadmium“ Project
- Results
- Concepts for Substitution

Introduction

■ Legislation of health hazard materials

- EEC Directives imposed on the marketing and use
- Implementation by passing legislation at a national level
(in Germany: Chemicals Prohibition Regulation)
- A few exceptions at the present legal situation

Introduction

■ Exceptions for cadmium

- aerospace
- military sector

➡ ***Cadmium may still brought into circulation and used***

■ Hazards to humans and the environment arise from cadmium

- manufacturing
- maintenance and repair jobs
- disposal

Cadmium-Related Health Risks

■ Items containing cadmium

- Minimal risk simply by touching
- Potential risk by processing and generating high temperature
 - grinding
 - filing
 - welding

➞ *cadmiumoxid fumes (inhaling)*

■ Cadmium-plating process

■ Waste disposal

Alternatives to Cadmium

■ Comparable substitutes

- zinc plating
- zinc-nickel plating
- alloyed special steels

■ Price of substitutes

- hardly differ in terms of price

➞ *No significant reason for continuing to use cadmium*

Cadmium Metal (Cd)

- Cadmium is a silvery white, shiny metal
- Good characteristics for corrosion protection
- ▢ *Surface treatment*

Hazards to Humans from Cadmium

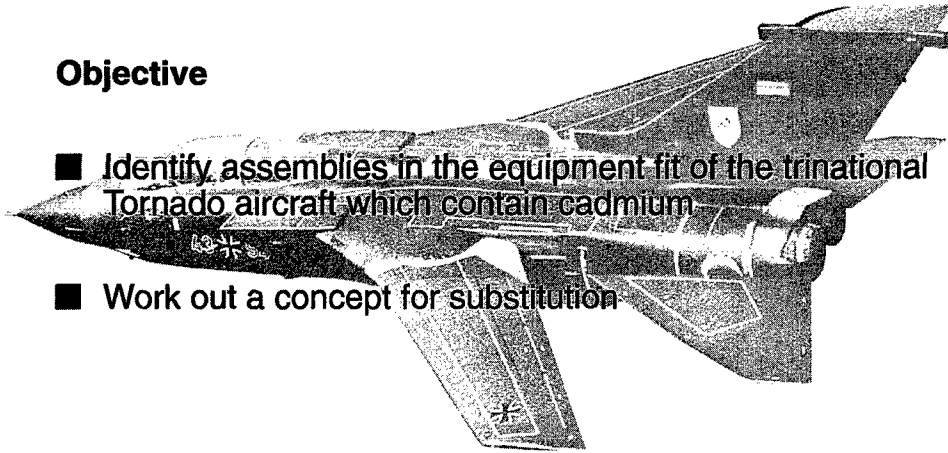
- Impairment of liver and kidneys (accumulation)
- Impairment of gastrointestinal tract
- Impairment of respiratory tract through inhalation of cadmium oxide
- Inflammation of mucosa ("cadmium cold")
- Destruction of olfactory epithelia
- Bone defects
- Suspicion of *carcinogenic effect*

➡ *Substitution of cadmium*

"Health Hazard Cadmium" Project

Objective

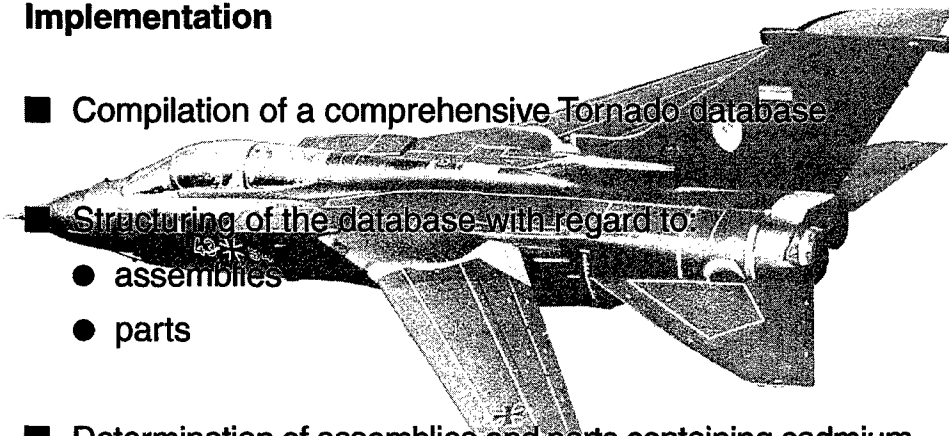
- Identify assemblies in the equipment fit of the trinational Tornado aircraft which contain cadmium
- Work out a concept for substitution



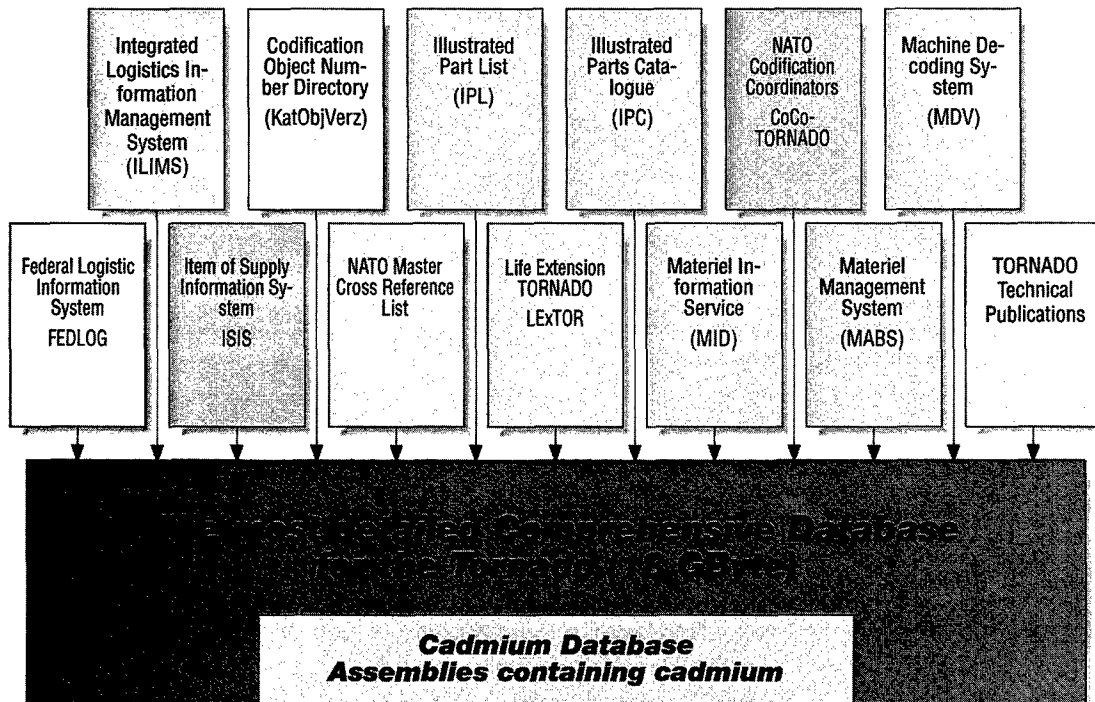
"Health Hazard Cadmium" Project

Implementation

- Compilation of a comprehensive Tornado database
- Structuring of the database with regard to:
 - assemblies
 - parts
- Determination of assemblies and parts containing cadmium



Compilation of the comprehensive Tornado Database

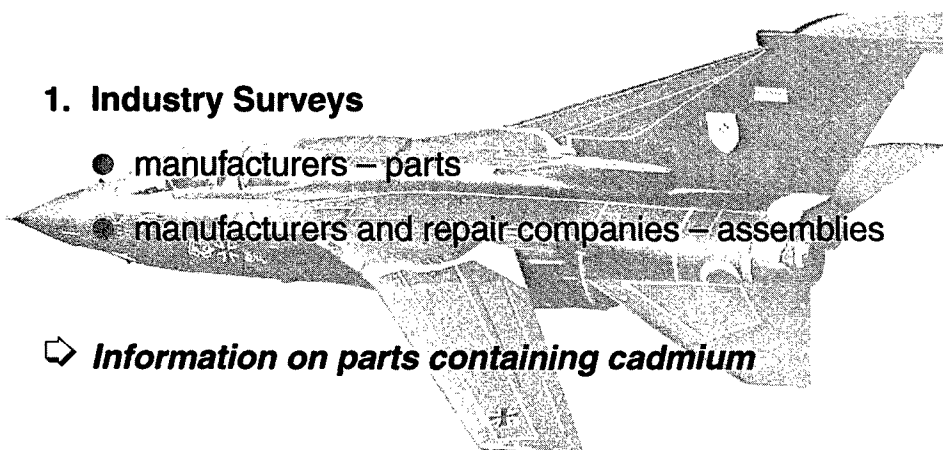


Identification of Assemblies Containing Cadmium

1. Industry Surveys

- manufacturers – parts
- manufacturers and repair companies – assemblies

➡ **Information on parts containing cadmium**



Identification of Assemblies Containing Cadmium

2. In-house procedures at ESG

- Requisite data by means of specific database queries
- Split into two groups:
 - parts *not containing cadmium*
 - parts *containing cadmium*

➤ *Volume of data that had to be assessed was successively reduced*

In-house Procedure at ESG

Names

- Name of on item of supply provides information on the group to which it has to be assigned

Descriptive Information

- Item of supply characteristics
- Details relating to material and surface treatment

Coding

- Unit of Issue – for example, unit for specifying liquids

In-house Procedure at ESG

Standards

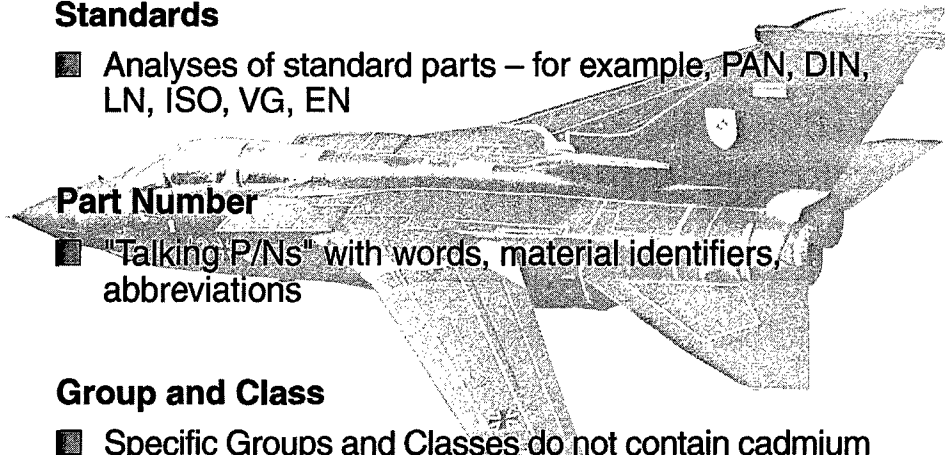
- Analyses of standard parts – for example, PAN, DIN, LN, ISO, VG, EN

Part Number

- "Talking P/Ns" with words, material identifiers, abbreviations

Group and Class

- Specific Groups and Classes do not contain cadmium

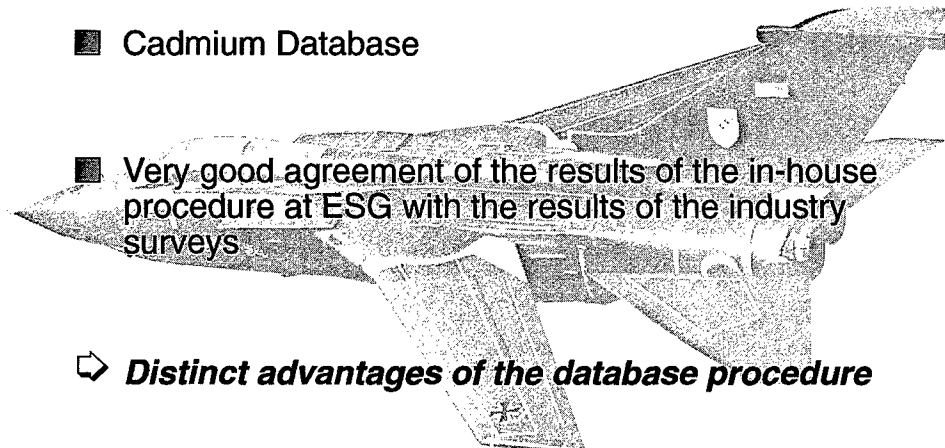


Results

- Cadmium Database

- Very good agreement of the results of the in-house procedure at ESG with the results of the industry surveys

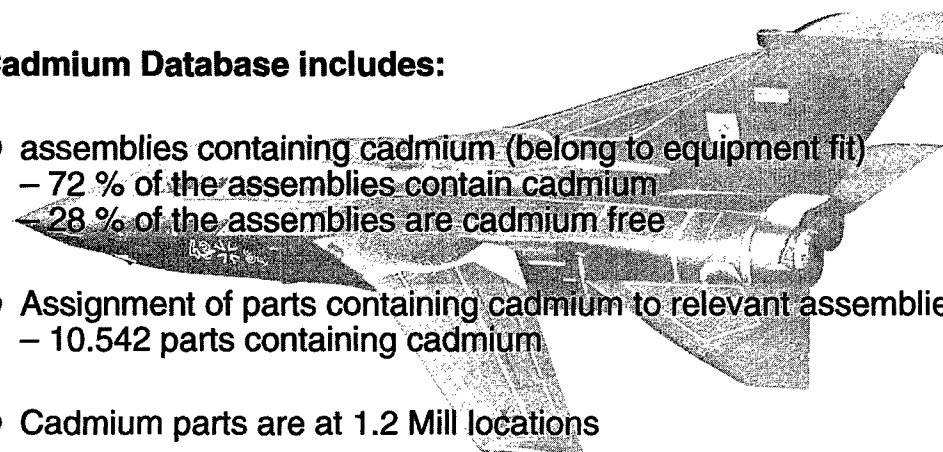
➡ *Distinct advantages of the database procedure*



Results

■ Cadmium Database includes:

- assemblies containing cadmium (belong to equipment fit)
 - 72 % of the assemblies contain cadmium
 - 28 % of the assemblies are cadmium free
- Assignment of parts containing cadmium to relevant assemblies
 - 10.542 parts containing cadmium
- Cadmium parts are at 1.2 Mill locations

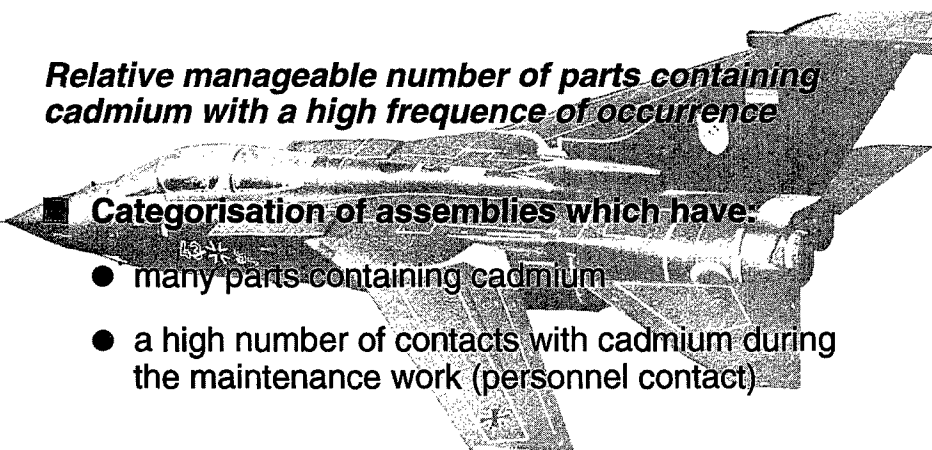


Concepts for substitution

Relative manageable number of parts containing cadmium with a high frequency of occurrence

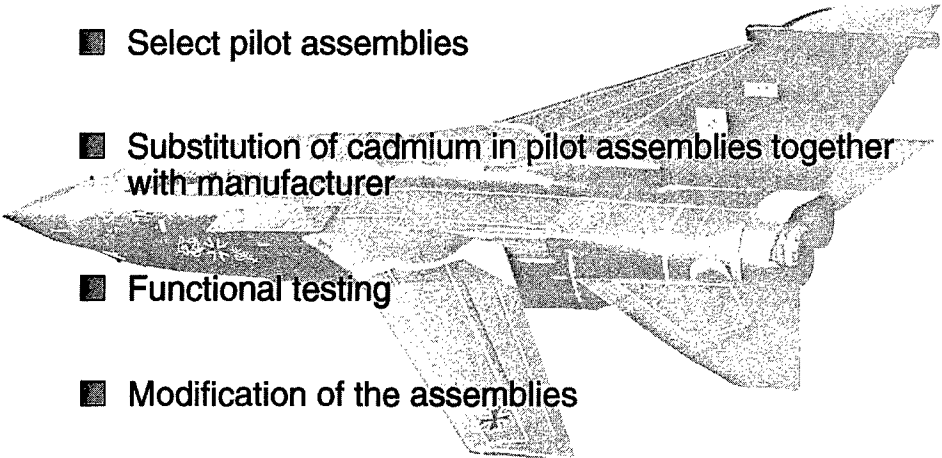
■ Categorisation of assemblies which have:

- many parts containing cadmium
- a high number of contacts with cadmium during the maintenance work (personnel contact)

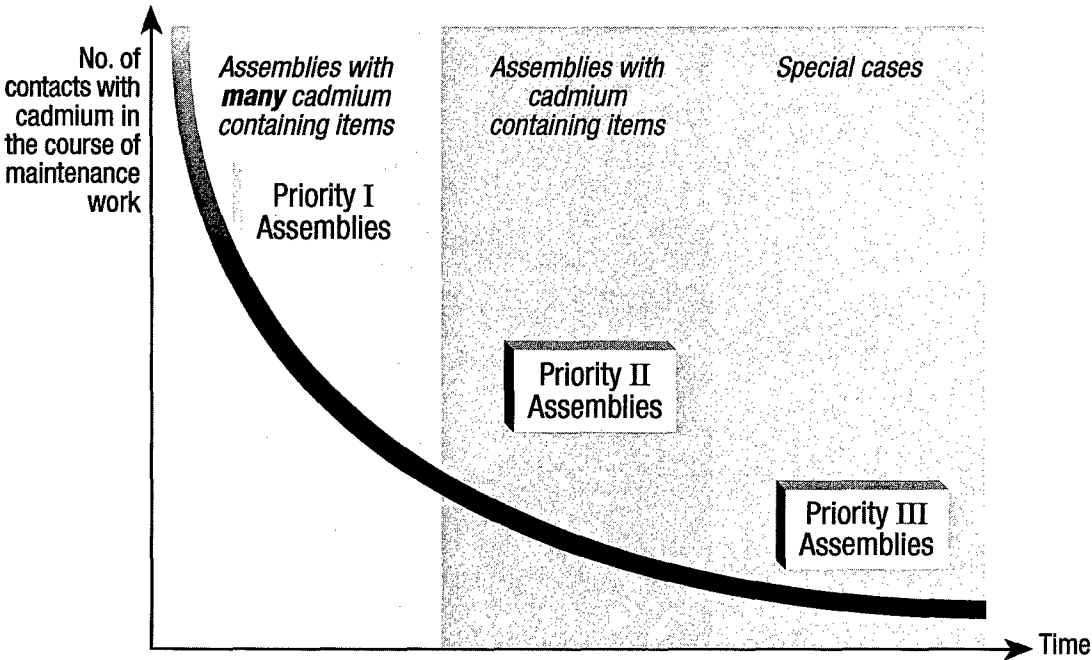


➔ **Permanent health risk by working with parts containing cadmium**

Concept for Substitution

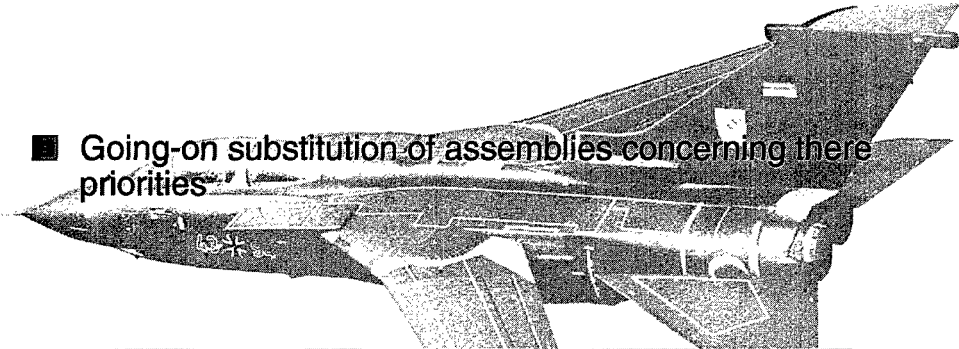


Assignment of Priorities to Assemblies



Concept for Substitution

■ Going-on substitution of assemblies concerning there priorities

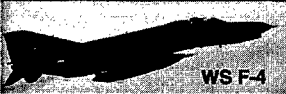


➡ *TORNADO could be freed from cadmium step by step!*

Projects for Environmental Conservation at ESG



Substitution of Tritium containing Luminous Paints



Substitution of Asbestos



Construction and Consumable Materials Database (WuV)



Operational and Auxiliary Materials Database (BuH)



Identification (and Substitution) of Cadmium containing Assemblies



Dataprocessing Procedures of Substitution and Standardization



PCB

Substitution of Capacitors containing PCB